DOCUMENT RESUME

ED 366 504 SE 054 126

AUTHOR	Peixotto, Kathleen M.
TITLE	A Vision of Science and Mathematics for All.
INSTITUTION	Northwest Regional Educational Lab., Portland, Oreg.
PUB DATE	Nov 93
NOTE	18p.; Paper presented the Annual Conference of the National Middle School Association (20th, Portland, OR, November 4-7, 1993).
PUB TYPE	Reports - Research/Technical (143) -- Speeches/Conference Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Cognitive Processes; Constructivism (Learning); *Critical Thinking; Educational Change; Educational Principles; Elementary Secondary Education; *Mathematics Education; Science Education; Scientific Attitudes; Standards; *Student Evaluation
IDENTIFIERS	Authentic Assessment; Science For All Programs

ABSTRACT

Many of those working to improve science and mathematics education have a vision where all students are successful and the celebration of success constantly presents the challenge to push the edge of the vision outward. The National Council of the Teachers of Mathematics established standards that some science educators are attempting to emulate. The vision of science and mathematics education represented in the standards is built on the themes of: (1) scientific and mathematical "habits of mind", (2) a constructivist approach to teaching and learning, (3) instructionally embedded assessments, and (4) science and mathematics for all. This paper discusses these themes and their implications for classrooms. (PR)

A Vision of Science and Mathematics for All

National Middle School Association
Annual Conference
Portland, Oregon
November, 1993

Kathleen M. Peixotto
Science and Mathematics Education Program
Northwest Regional Educational Laboratory
101 SW Main Street
Portland, Oregon 97204
(503) 275-9498

A Vision of Science and Mathematics For All

Introduction

"The trouble with educators is that they seek one grand theory to address all problems." (Anonymous). Although certainly an overstatement, most will agree there is truth in this statement. A recent editorial in a Vancouver, Washington newspaper suggested that "what's wrong with education is that too much of it is not education; it is instruction." The editorial continues, "education in a classical sense meant the opening and developing of mental faculties, the expansion of the mind. Instruction considers the mind a vessel of certain capacity into which a collection of approved items should be fitted by experts." (*The Columbian,* October 31, 1993). An examination of past reform efforts emphatically points to the multitude of "quick fixes" attempted and abandoned in a search for "the answer" to our problems in education. Raising graduation requirements or college-entrance requirements, lengthening the school day, providing new avenues for alternative teacher certification, implementing new testing programs, expanding the curriculum all represent previous piecemeal attempts to improve our schools. Despite all these efforts, many contend that most schools today don't look very different from those of 30 years ago.

Is the picture really this dismal? Are we just "spinning our wheels" -- continually attempting to improve without any significant results? A "reality check" would bring to light numerous classrooms and schools where effective education is happening and it is always important to celebrate these successes. However, today, many of those working to improve science and mathematics education have a vision where **all** students are successful and the celebration of success constantly presents the challenge to push the edge of the vision outward. The philosophy of a systemic approach to reform embraces this ideal. Today's systemic approach to change requires a holistic approach -- no one part of the system is adjusted without affecting other elements also operating in the system. Systemic change:

- focuses on the concept that all students can be successful learners
- integrates the preservice and inservice professional development of educators
- articulates a vision and desired outcomes that serve to "steer" and "coordinate" the change process
- provides for concrete mechanisms to bring people together across roles, levels, and organizations
- includes provisions for ongoing inquiry and/or research into teaching and learning
- constitutes a "mainstream" activity -- not an alternative or special program

What might be the impact of systemic reform on science and mathematics education? How will the results of systemic reform look different from what we have done before? What makes systemic reform different from past efforts?

For now, consider this tale of two classrooms.

> Ms. Judge's eighth-grade science class is listening--a charitable term given the noise level--to a lecture about photosynthesis. Textbooks lie open. On the blackboard is a drawing--a rather adept one in colored chalk--of a plant, the sun, and the soil, with arrows connecting them. In the middle of Ms. Judge's explanation of the roles of carbon dioxide and water, Nick, a bright student who only occasionally achieves at his potential, asks "Is this going to be on the test?" When Ms. Judge answers yes, the conversational buzz subsides and note-taking increases, but the teacher wonders whether any of her students really care.
>
> Down the hall, Ms. Gioia holds up a potted green plant and poses the question: how do plants come by their food? "They make it themselves," says Crystal, and most of the other students nod. Although someone interjects the term "photosynthesis," Ms. Gioia realizes through follow-up questions that no one really knows what this concept means, or what plant food is. She then challenges the class to help her design an experiment that would clarify the issue. Students congregate in small groups, debating how to structure an experiment that examines the amount of light that different plants

need, which they will eventually graph and expand to include other variables (Kober, 1993).

These vignettes depict two different approaches to motivating students toward understanding important concepts in science. The students in Ms. Judge's class are motivated to tune in when she mentions "the test", but she seems to sense the failure of this approach to honestly motivate her students toward acquiring the meaningful knowledge and skills of science. Imagine these eighth-grade students as sophomores in high school. Which students do you think will be more likely to elect additional science courses? Which students will be more likely to remember and be able to apply the skills and concepts of their middle school science experiences? Which students are more likely to be successful as future workers in the "real-world"?

Current reform efforts in science and mathematics education suggest Ms. Gioia's students are receiving the experiences that many believe will best equip students to live and work in the 21st century. Several common themes are significant and emerge when one looks at any of the multitude of reform movements presently operating in the mathematics and science education communities. The National Council of the Teachers of Mathematics (NCTM) publication in 1989 of the Curriculum and Evaluation Standards for School Mathematics established a model science educators are attempting to emulate. Concerted efforts by the National Science Teachers Association (NSTA), the American Association for the Advancement of Science (AAAS) and the National Committee on Science Education Standards and Assessment (NCSESA) all echo a vision for science curriculum, assessment and teaching depicted in the NCTM standards. This vision of science and mathematics education represented in the standards is built on the themes of: 1) scientific and mathematical **"habits of mind"**, 2) a **constructivist** approach to teaching and learning, 3) **instructionally embedded assessments**, and 4) **science and mathematics for all.**

Habits of Mind

The idea of "habits of mind" suggests an approach to science and mathematics education requiring more than regurgitation of a set of specific facts, vocabulary terms or algorithms. "Habits of mind" implies a way of thinking -- an approach to problem-solving and an ability to apply knowledge. Another closely related concept, "less is more" compliments what is at the heart of habits of mind. Less is more, a concept proposed by Ted Sizer in his work with the Coalition of Essential Schools, is grounded in the basic premise of depth vs breadth. The two ideas of habits of mind and less is more are closely linked -- adoption of one principle necessitates a commitment to the other. To fully develop the essential habits of mind of science or mathematics, requires an in-depth rather than cursory exploration of either discipline. To merely be able to diagram the steps of the Krebs Cycle, complete a series of problems in long-division or balance a set of chemical equations does not really demonstrate the "habits of mind" of science or mathematics. To demonstrate the habits of mind essential to these disciplines requires a higher level of thinking and an application of knowledge, unfortunately absent in many of today's classrooms.

Let us return to Ms. Judge's and Ms. Gioia's classrooms and consider the habits of mind fostered by the two different approaches to the concept of photosynthesis. How would you characterize the style of the first classroom? Fact-based, textbook and teacher-centered, focused on the "right answer" for the test, students passive and uninvolved, might be some phrases we could use to describe the classroom. And yet, we also have the sense that Ms. Judge is a caring teacher -- one who is concerned about her students and the science discipline. In contrast, the second classroom might be described as student-centered, focused on inquiry and experimentation, and a place where students are actively involved in the learning process. It is important to point out that the vignette does not lead us to believe that Ms. Gioia's students actually "know" more about the concept of

photosynthesis, but rather that these students will likely have experiences and opportunities that will encourage and facilitate the development of the important habits of mind associated with science as a discipline.

We must accept what we intuitively know--it is impossible to learn or teach everything there is to know. However, an examination of many science textbooks or state/district curriculum guides would lead us to believe that is exactly what is expected. Even if we were able "to cover" the entire textbook or course guidelines, our students would probably quickly forget most of what is "covered" simply because as human beings we tend to forget much of the information we do not use (Marzano, 1992). The idea of habits of mind serves to guide educators wrestling with this dilemma. Obviously, acquiring content knowledge is essential and a necessary outcome of schooling -- habits of mind simply suggests that the acquisition of the content is not the most important goal. If these habits of mind lead students toward developing the ability to identify what they need and want to know, the skills to acquire or access the needed information, and the attitudes and reasoning powers necessary to apply this knowledge and information, we will likely be successful at preparing our students for the challenges of the next century.

What are the necessary habits of mind for success in science and mathematics? Another story is helpful in answering this question. Reportedly based on a true story (Marzano, 1992) the setting is an advanced placement calculus class:

> Mr. Washington's students have already learned his approach to mathematics is somewhat different than other teachers they have had. For one thing, he doesn't always emphasize just getting the right answer, but expects students to "try to be accurate" in what they do and to "hang in there, even when the answers aren't immediately apparent." It's not that Mr. Washington doesn't care about the right answers, but rather that he thinks anyone can learn almost anything if they've learned to "discipline" their minds in certain ways.
>
> To illustrate his point, Mr. Washington tells his students about a friend of his from college, Dan King. According to Mr. Washington, Dan wasn't "terrifically smart but he was determined."

> As a junior in college Dan made a commitment to follow in his father's footsteps and get a Ph.D. in mathematics. But his plans to pursue the graduate degree were interrupted by the Vietnam war. Tragically, two weeks before Dan was scheduled to come home, he was blinded by a grenade. Mr. Washington tells of his surprise when his friend Dan remained committed to the advanced degree in mathematics. "I thought that because math is such a visual subject there was no way he could do such abstract work with his disability." However, five years after his return from Vietnam Dan received his Ph.D. in mathematics.
>
> "How do you think he did it?" Mr. Washington asks his students. A lengthy discussion follows, resulting in the students generating a list of things Dan probably had done to accomplish his goal:
>
> 1) made a plan
> 2) used his resources
> 3) changed what he was doing when things weren't working out
> 4) hung in when the going got tough
> 5) trusted his own ideas and abilities
> 6) got people to help him
>
> When the list is complete, Mr. Washington tells his students. "These are the things that are important to me. Not just calculus. This is what we're going to practice in here."

These are the habits of mind for success in Mr. Washington's calculus class. Are they more important than the content? Are they equally as important? These questions are best answered when educators, parents, community and business leaders come together and participate in a dialogue of vision-building activities to collectively answer the critical question: **"What do we want our students to know and be able to do?"**

The habits of mind identified by Mr. Washington's class are valuable and necessary components of a student's education. In their work to develop the national science standards, the NCSESA targets inquiry as the scientific way of knowing. "Inquiry is the process by which scientists pose questions about the natural world and seek answers and deeper understanding, rather than knowing by authority or other processes. Approaching the study of school science in a questioning mode is, therefore, in harmony with the practice of science, as compared with presenting science by talking about it." (National

Research Council, 1993). The national standards identify the essential habits of mind required to practice this inquiry process as:

- intellectual honesty
- skepticism
- tolerance of ambiguity
- openness to new ideas
- communication and sharing.

Constructivist Learning Theory

The theme of habits of mind, however, is only one aspect of the emerging vision in science and mathematics education. In a classroom where the emphasis is on the student as learner rather than the teacher as imparter of knowledge, learning is an active process. The cognitive theory of constructivism proposes that knowledge can not be simply transferred by language especially when the goal is more than the mere acquisition of information. Some suggest that too many classrooms continue to employ the behaviorist model of learning. In this model the teacher provides a series of stimuli, followed by appropriate positive or negative reinforcements, in an attempt to elicit certain appropriate responses from students. The scenario presented in Ms. Judge's more traditional class represents a behaviorist approach to learning. Although appropriate and effective in certain circumstances, the approach frequently fails when the goal becomes understanding, synthesis, application, and the ability to use the information in new situations.

Consider the example of the classroom where a group of students is given the problem of determining how many buses are needed to transport "1,128 soldiers when each bus can accommodate thirty-six people." As the story goes, the students are able to correctly perform the necessary computations but report the result as the inappropriate answer of "thirty-one, remainder twelve" (Gardner, 1993). The drill and practice of a traditional approach to mathematics education provides students with the needed skills,

but little or no understanding of the concept or the ability to make an application of these skills. Contrast this with a classroom where the constructivist approach is employed:

> For an entire academic year students in a 6th grade mathematics class studied ratios and proportions. The lessons were designed to develop students' proportional reasoning abilities. The objectives were explored--not "covered"--in the natural and spontaneous context of students' thinking. While comparing the radii of circles given the circumferences, for example, students *asked* for a review lesson on the division of decimals. They had come to the mature conclusion that to solve a real problem, they needed an arithmetic skill (Brooks, 1990).

In constructivist classrooms students are encouraged to generate questions and problems that become the basis for the topics of study. Students are held responsible for their learning and are expected to "take action" as a part of the learning process. Whenever possible, the use of local resources and primary data sources are used in the process. Constructivism fosters tasks that are associated with the verbs *predict, justify, reflect, analyze,* and *challenge*. The power of the theory is suggested in yet another classroom example from the 6th grade mathematics class described above:

> Students are trying to determine whether there is any relationship between the radius of a circle and its circumference. After experimenting with construction paper, some string, a ruler, and a pencil, one student responds: "I think I've come up with something. If you take the number around a circle and divide it by the line going across, no matter how big the circle is, you always get about 3!"

As Brooks relates this incident, "the child, approximating the value of pi, had seen it as a ratio of two other features of a circle. Who do you think will be more likely to understand and remember the meaning of pi -- a child introduced to the concept as an element in a formula or this discovering child?" The habits of mind as well as the content and process skills of science and mathematics are nurtured in a constructivist environment. However, utilizing a constructivist approach to teaching and learning cannot then be abandoned when it comes time to assess what students know and are able to do. The

tenets of the theory must be stretched and applied to assessment as well if the emerging vision of science and mathematics education is to be attained.

Instructionally Embedded Assessments

Instructionally embedded assessments represent yet another component of the system. Some suggest assessment may in fact be the critical leverage point in the system (Gong, Venezky, & Mioduser, 1992). Effective change in assessments can ripple throughout the educational system affecting curriculum, teaching strategies, resources, attitudes and policy. A positive effect is most likely when the assessment is an integral aspect of the curriculum as opposed to separate and "after the fact". Instructionally embedded assessments, as the name implies, are closely linked to curriculum and instruction. Assessments of this type are designed to be used to inform both students and teachers of the process as well as the progress in learning. Instructionally embedded assessments help to "focus teachers' and learners' attention on the critical dimensions and concepts of the discipline and encourage an **instructional partnership** of teacher and learners in the classroom." (Gong, et al, 1992). The increasingly popular use of journal writing in mathematics classrooms is an excellent example of this type of assessment. Another application is described by Diana Prichard, an 8th grade math and language arts teacher, who asks students to correct problems they have missed on a test, not by simply doing the problem again, but by also writing about why they missed the problem. The value of this exercise is revealed through the teacher's words.

> I read these explanations from two students who missed the same problem: One wrote, "I didn't know what 'prime factorization' meant." The other student wrote, "I didn't know what 'express' meant." Both students missed the problem, but for very different reasons. One had difficulty with a mathematical concept. The other simply had a general vocabulary problem. (Batey and Hart-Landsberg, 1993).

Consider again our question **"What do we want students to know and be able to do?"** Traditional assessments suggest the answer to this question would be:

- There is always one right answer to math and science problems.
- Computation is central to math and science.
- Knowing is more important than being able to do.
- Science and math are primarily done with paper and pencil.
- Being able to recognize technical terms is more important than understanding and applying concepts.
- Some external authority is the only valid judgment of whether an idea in science and mathematics is acceptable and true.

Our question, however, would be answered very differently with a focus on using instructionally embedded assessments. Characterized by higher order cognitive processes (application, synthesis, reflective evaluation), problem-solving, real life situations, multiple responses and formats, instructionally embedded assessments provide rich and informative feedback to both student and teacher. Blurring the lines of assessment and instruction is a powerful tool to be used in building and implementing a science and mathematics education vision. A vision that must also incorporate the belief that **all** students can and should be mathematically and scientifically literate.

Science and Math for All

The message is clear. From A Report to the Nation on the Future of Mathematics Education: "It is vitally important for society that *all* citizens benefit equally from high-quality mathematics education" (National Research Council, 1989). From Project 2061: Science For All Americans: "Scientific literacy. . . has emerged as a central goal of education. . . the understandings and habits of mind (that) are essential for *all* citizens in a scientifically literate society" (American Association for the Advancement of Science, 1989). From EDTALK: What We Know About Science Teaching and Learning: "All students--not just a talented few--need an in-depth understanding of science; all students have the ability to achieve this understanding if they are taught in ways that encourage and

build upon their natural curiosity and other abilities" (Kober, 1993). Science and mathematics education must address and meet the needs of all students. These disciplines must become the pump, rather than the filter, that pushes students into the pipeline toward success and opportunities in a technologically oriented world. Achieving this mandate requires special attention to equity issues and those students traditionally underrepresented in science and mathematics, females and minorities.

"Despite notable increases in recent years, women and minorities continue to be significantly underrepresented among the ranks of the Nation's scientists and engineers in proportion to their numbers in the overall U. S. work force" (NSF, 1992). Women constitute 51% of the total population, 45% of the work force, but only 16% of all scientists and engineers employed in the U.S. Blacks comprise 12.1% of the total population, 11% of the work force but represent only 3% of employed scientists and engineers. Hispanic workers account for 9% of the population, 5% of the work force and 2% of scientists and engineers. "Native Americans in science are so rare that the numbers are statistically suspect." (Sims, 1992).

Walter Massey, a physicist, director of the National Science Foundation and an African-American writing in Science magazine illuminates one reason for the pervasive and tenacious underrepresentation of women and minorities in science and engineering:

> The culture of science and engineering may contribute to this failure. The common concept of "success in science" I mentioned earlier seems to have created an illusion that only "the best and the brightest" can do science. Coursework is viewed by many faculty as a way to separate the "men" from the "boys." Unfortunately, these courses also tend to separate the men from the women--and the white men from just about everyone else (Massey, 1992).

Decades of gender equity research provides evidence to suppr t Massey's conclusions and suggests strategies to be employed in attempting to dispel the inequities. One segment of the research focuses on the long history of cultural biases and stereotypes prevalent in American society. When asked to draw a picture or describe a scientist or

mathematician, students will consistently depict a masculine figure. The perception of mathematics or science being "too hard" or not for girls is a message delivered by parents, teachers, counselors and even toy companies! The recent release by Mattel Toys of the "talking" Barbie doll whose comment "Math class is tough" exemplifies this attitude. Research suggests that more subtle biases are in also in effect. Evidence indicates boys' play experiences, which typically provide opportunities to explore, manipulate and take risks, are more conducive to success in the practice and pursuit of science, but are absent from many girls' typical play time activities.

Another segment of equity research reveals the effect of students' attitudes and self-concepts on their selection of and success in science and mathematics courses and careers. In 1992, the American Association of University Women (AAUW) published the report How Schools Shortchange Girls, a review of gender research conducted over the past 20 years. Among the multitude of studies reviewed, seven reported the same findings--girls believe the success they typically achieve results from luck, while boys see their success as a result of effort -- leading to what researchers term "learned helplessness". The AAUW report clearly documents the critical arena of the classroom. Student-teacher interactions send powerful messages to students. Not surprisingly, teachers are frequently unaware of their behavior. A seventh grade teacher, describing herself as coming from a family with a number of strong female role models comments: "I would have said I favored girls in my classroom interactions." However, after participating in an exercise designed to document possible bias in the classroom, she surprisingly admitted "the truth was, I not only called on boys more often, I talked to them differently, too."

Although, the vision of science and math for all is meant to be interpreted in the broadest sense -- it is important to consider strategies that can be employed to specifically encourage women and minorities. Many believe these strategies will do a better job of encouraging all students -- not just girls, not just Hispanic students, but also the white

male student who turns away from these subjects. "If there's one message that has emerged from the past 20 years of trying to bring minorities into science, it is this: Efforts to stem the hemorrhage of students out of the pipeline must start early and continue through college." (Science, 1992). The issue of attracting and retaining students in the science and mathematics pipeline must be addressed through a variety of strategies. Current research suggests certain strategies are effective. However, there remains a need for substantive longitudinal data on the effectiveness of programs, strategies and interventions implemented in an attempt to ensure the participation of those traditionally underrepresented.

In the classroom, teachers can chart and tally their own interactions with students. Video taping a lesson provides excellent feedback not only on the frequency of interactions with various students, but also serves as a tool to observe and analyze the nature of the interactions. Are all students challenged with questions requiring higher-order thinking? Don't always require "the right answer" -- encourage predictions, reflective thinking, and evaluation and defense of conclusions. Is the language gender-neutral and free from stereotypical comments? Although intended to be generic and inclusive, "mankind" does send a message. If the "generic" term was "womankind" would male students feel included? Students must also be challenged to examine their own biases and stereotypical attitudes. Are female students encouraged to take risks? Don't allow passive behavior -- require participation Girls need to have opportunities to set up and manipulate laboratory equipment -- boys need to have opportunities to act as the recorders and wash the equipment. Provide opportunities for single-sex laboratory or cooperative groups as well as more heterogeneous groupings.

Current research indicates that role models and mentoring are two of the most effective strategies to be employed when encouraging females and minorities to participate in science and mathematics. Almost all women and minorities who have remained in the

pipeline give credit for their tenacity to someone -- a parent, teacher or mentor who wasn't satisfied until they did well.

> High school senior Erin Locklear, a Lumbee Indian from Fairmont, North Carolina, remembers teachers telling her American Indian friends to "just do what you can." She herself ignored this advice, because her parents expected her to excel. "I'd come home with a 97 on a test and my dad would say, 'Where are those other three points?' " (Science, 1992).

Active recruitment, encouragement, and support are strategies that do pay off. Women and minorities are increasingly selecting and staying with science and mathematics in school and as careers. However, in our quest of science and math for all, the search for effective strategies and success must continue to be purposeful, reflective and multi-faceted.

Science and math for all will only be accomplished through:

- a shared vision
- high expectations
- coherent and cohesive efforts
- involvement of all constituencies
- commitment to personal mastery through continuous growth and change

These are also the elements of systemic reform. Science and math for all -- a vision, a goal for American schools of the 21st century. Systemic reform, habits of mind, constructivism, and embedded instructional assessments provide the tools, the mechanisms, and the principles for achieving the goal. Skeptics and nay-sayers tell us to ignore these ideas, arguing that as educators we are again caught up in another "quick fix" or trendy idea. Optimists and idealists want to believe we are on the right track. Realists are working to make it happen -- realizing that worthwhile reform is a slow process that must overcome numerous barriers. Which one are you?

References

AAUW Educational Foundation (1992). **How Schools Shortchange Girls.** Researched by the Wellesley College Center for Research on Women. Washington, D.C: AAUW Educational Foundation.

American Association For The Advancement of Science (1989). **Project 2061: Science for All Americans.** Washington, D. C.: American Association for the Advancement of Science.

Batey, Anne and Sylvia Hart-Landsburg. (1993). **Riding The Wind.** Portland, OR: Northwest Regional Educational Laboratory.

Brooks, Jacqueline G. (1990). *Teachers and Students: Constructivists Forging New Connections.* **Educational Leadership.** Volume . Pg. 68-71.

Culotta, Elizabeth. (1992). *Scientists of the Future: Jumping High Hurdles.* **Science.** Volume 258. Pg. 1209 -1213.

Gardner, Howard. (1993). **Multiple Intelligences. The Theory in Practice.** New York: Basic Books.

Gong, Brian, Richard Venezky and David Mioduser. (1992). *Instructional Assessments: Lever for Systemic Change in Science Education Classrooms.* **Journal of Science Education and Technology.** Volume 1. No. 3. Pg. 157-176.

Kober, Nancy (1993). **EDTALK. What We Know About Science Teaching And Learning.** Washington, D. C.: Council for Educational Development and Research.

Marzano, Robert. J. (1992). **A Different Kind of Classroom.** Teaching With Dimensions of Learning. Alexandria, VA: Association for Supervision and Curriculum Development.

Massey, Walter E. (1992). *A Success Story Amid Decades of Disappointment.* **Science.** Volume 258. Pg 1177-1179.

National Committee on Science Education Standards and Assessment. (1993). **National Science Education Standards: An Enhanced Sampler.** Washington, D.C.: National Research Council.

National Council of Teachers of Mathematics (1989). **Curriculum and Evaluation Standards for School Mathematics.** Reston, VA: The National Council of Teachers of Mathematics, Inc.

National Science Foundation (1992). **Women and Minorities in Science and Engineering: An Update.** NSF 92-303.

National Research Council. (1989).**Everybody Counts.** A Report to the Nation on the Future of Mathematics Education. Washington, D. C.: National Academy Press.

Sims, Calvin. (1992). *What Went Wrong: Why Programs Failed.* **Science.** Volume 258. Pg. 1185-1187.